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SURFACE ENERGY BUDGET OF THE TROPICAL PACIFIC OCEAN

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Abstract

The four components of the net surface heating of the tropical Pacific Ocean between 40°S and 30°N have been calculated for each month between January 1957 and December 1976. The 20-year monthly mean of each component were also calculated. These flux estimates were derived by using "bulk formulae" and about five million marine weather reports. The components are averaged over 5° latitude by 5° longitude grids. Grids which did not have data in a given month were assigned interpolated values.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The four components of the net surface heating of the tropical Pacific Ocean between 40°S and 30°N have been calculated for each month between January 1957 and December 1976. The 20-year monthly mean of each component were also calculated. These flux estimates were derived by using "bulk formulae" and about five million marine weather reports. The components are averaged over 5° latitude by (over)

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Figure 5. Report Documentation Page.

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5° longitude grids. Grids which did not have data in a given month were assigned interpolated values.

MARINE DATA ANALYSIS SUBSYSTEM

Background

The MARine Data Analysis Subsystem was designed as a data editing and data reduction system to support the analysis of energy flux in the tropical Pacific Ocean. Data from the Consolidated Data Set of Marine Observations (TDF-11) and the FNWC Marine Climatological Data (Fisheries Data) were merged to form a comprehensive set of marine surface observations for the period 1957-1976. The resultant data set of total marine observations is organized into a system of 5-degree-grids over the entire study area. Ship reports within each grid are stored chronologically - a single record being stored for each report.

Phase I Processing

The objective of the first phase of MAR-DAS is to edit and consolidate the TDF-11 and Fisheries data. The two data sets were separately edited to remove duplicate records and erroneous reports. Editing of TDF11 records resulted in an approximate rejection of 5% of the reports within the study area. The editing procedures rejected roughly 10% of the reports from the Fisheries data set. The editing procedures produced annual and summary density maps of the number of reports within each 5-degree-grid.

The outputs from the editing process were a series of packed binary files of ship reports for the study area. Each report was compacted into a 3 word 60 bits/word record with the first word containing a sort key. These compressed records were sorted into a separate latitude, longitude, and date order for each of the TDF-11 and Fisheries data sets. The sorted data sets were merged to form the total marine observations file.

Because of the large volume of data in the final marine observations the data is organized into 54 separate volumes. These volumes are based on latitude and longitude of the observations. Northern latitudes with high density observations are organized into volumes of smaller area (fewer 5-degree-grids) while southern areas encompass more area per volume. (Refer to Appendix D for a map of the volume organization). A volume is subdivided into a file for each 5-degree-grid it contains. Thus a particular 5-degree-grid may be accessed by a particular volume and file name. Data within the 5-degree-grid (file) is organized as a simple sequential file with ship reports stored in chronological order.

Phase I processing resulted in the consolidation of approximately 5 million ship reports of marine surface weather conditions within the study area from 1957-76. Density and contour maps of the reports by area were produced as a part of the Phase I procedures.

Phase II Processing

The second phase of the MARDAS performs data reduction and graphical analysis tasks. The marine observations data created by Phase I was the source data for Phase II operations. Long term statistical values are calculated for each month over the 20 year study time. The number of observations, mean, and standard deviation of eleven values are determined for each five degree grid. These statistics were stored on a single volume (SEALNG). This direct access file contains the statistics for each 5-degree-grid. Thus, the long term statistics for a single 5-degree-grid may be accessed directly rather than sequentially.

A second process in the data reduction procedures is the creation of short term statistics. These short term statistics are calculated for each unique month and year within the study period. The statistics include means and variances for each of the five reported variables (U, V, Ta, Ts, and qa) and the mean fluxes for a number of calculated values (Umag, qs, P, N_L, N_T, C_E) as well as the vertical and horizontal flux components. The short term statistics are split into two distinct output volumes. The first volume contains the statistics for the "primary" variables (U, V, Ta, Ts, and qa) the second volume contains statistics for the remaining ("secondary") variables. The files of both groups of short term statistics are organized as maps of data over the study area at a point in time (a particular month and year). Organization of the primary and secondary variables are identical. Each variable category (primary or secondary) is organized into its own volume. Within each volume a file exists for each year of the study and each file is sub-divided into direct access records for each calender month within the year. All the statistical data for a unique year and month are thus recorded in a single record. An additional monthly record (month = 13) and an additional yearly record (year = 21) are also stored in the volumes Month = 13 contains the mean yearly values for the years 1957-76. The file years = 21 contains the 20 year means for each month and the total mean for all data (month = 13).

The final portion of the Phase II operations is a system of graphical and curve smoothing routines. These routines are used to produce maps and contours of the calculated statistics and raw data in the marine observations files.

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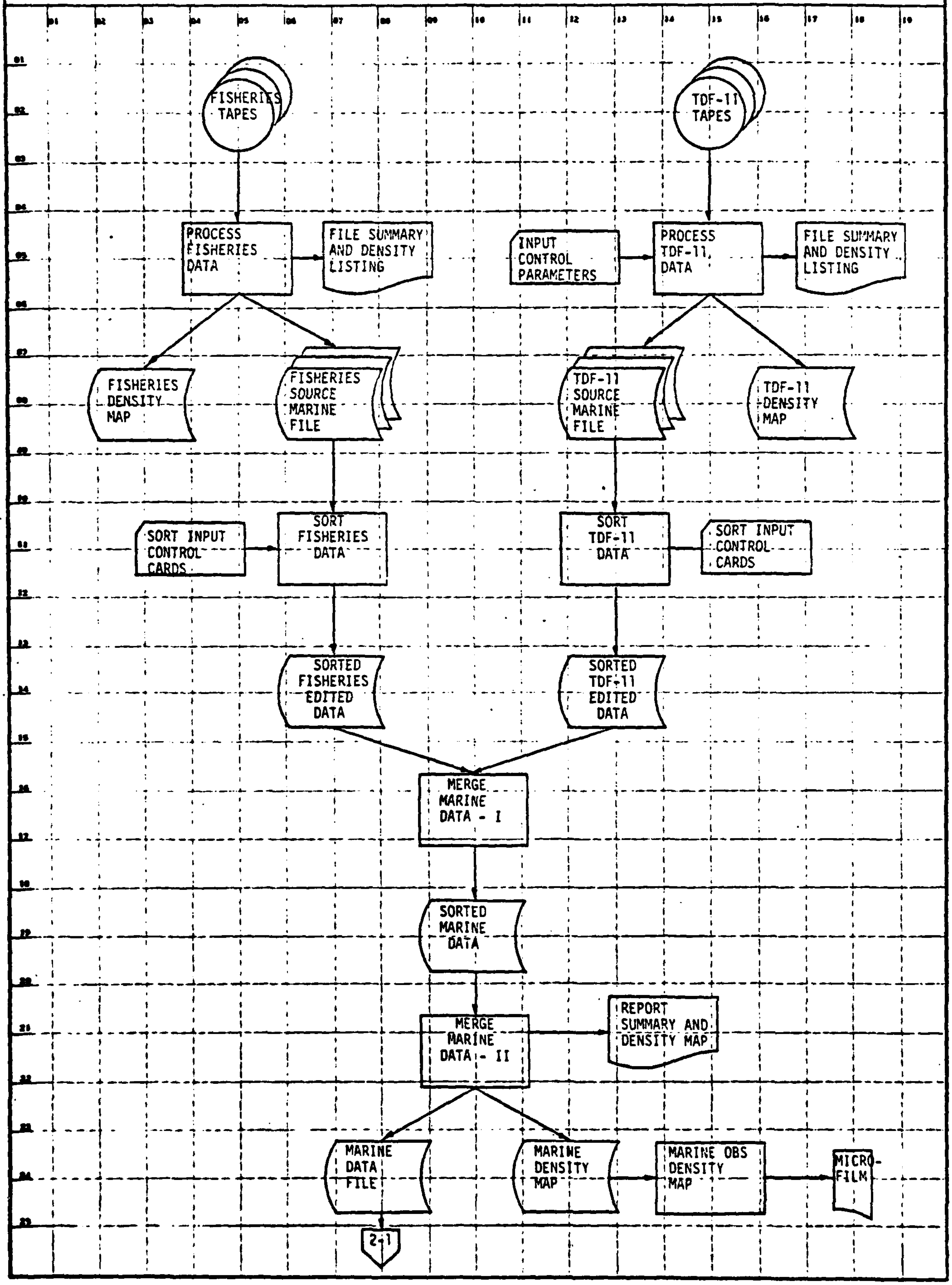
Procedure SYSTEM OVERVIEW Drawn By M. SAMUEL



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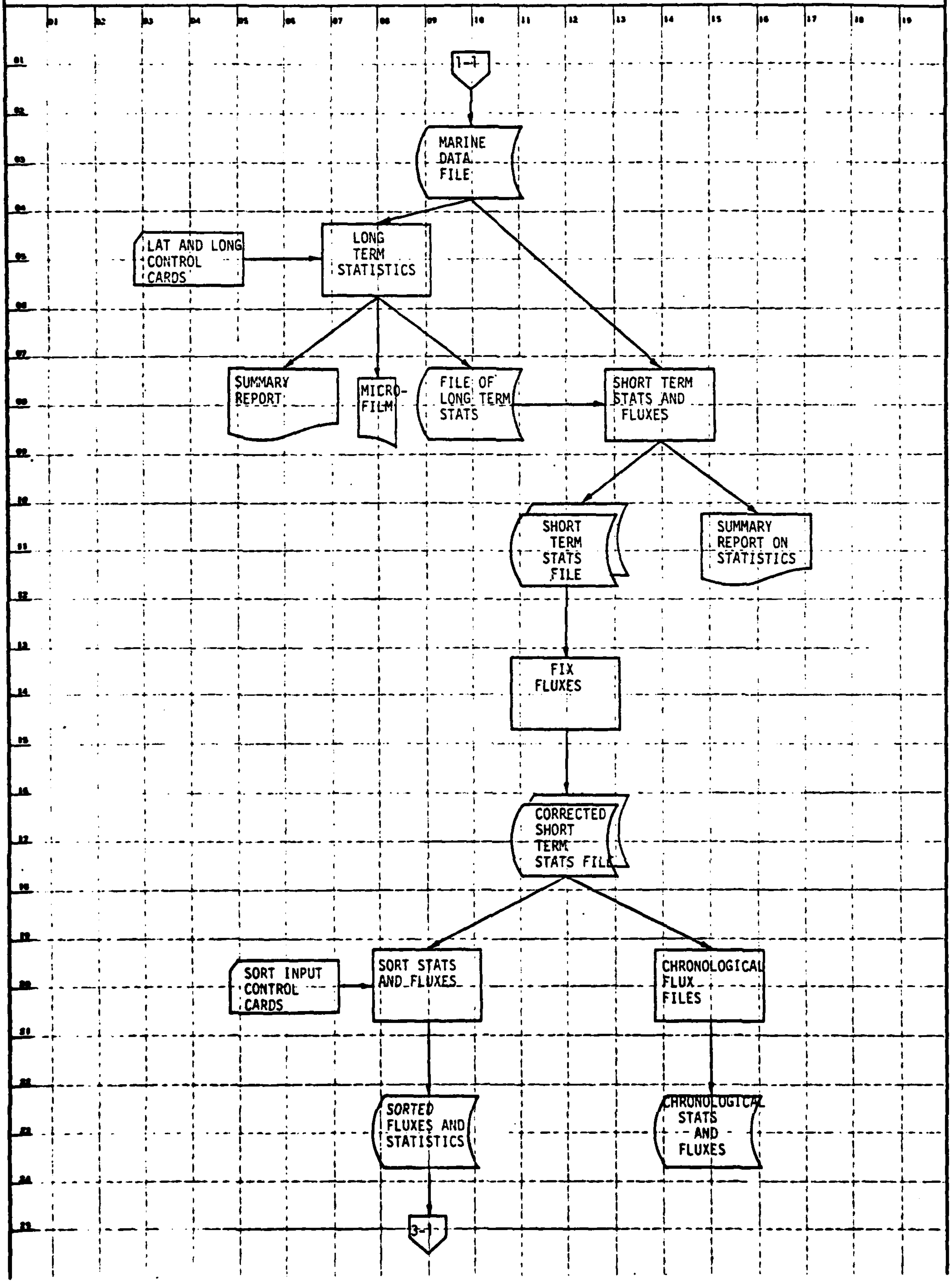
Procedure SYSTEM OVERVIEW Drawn By M. SAMUEL



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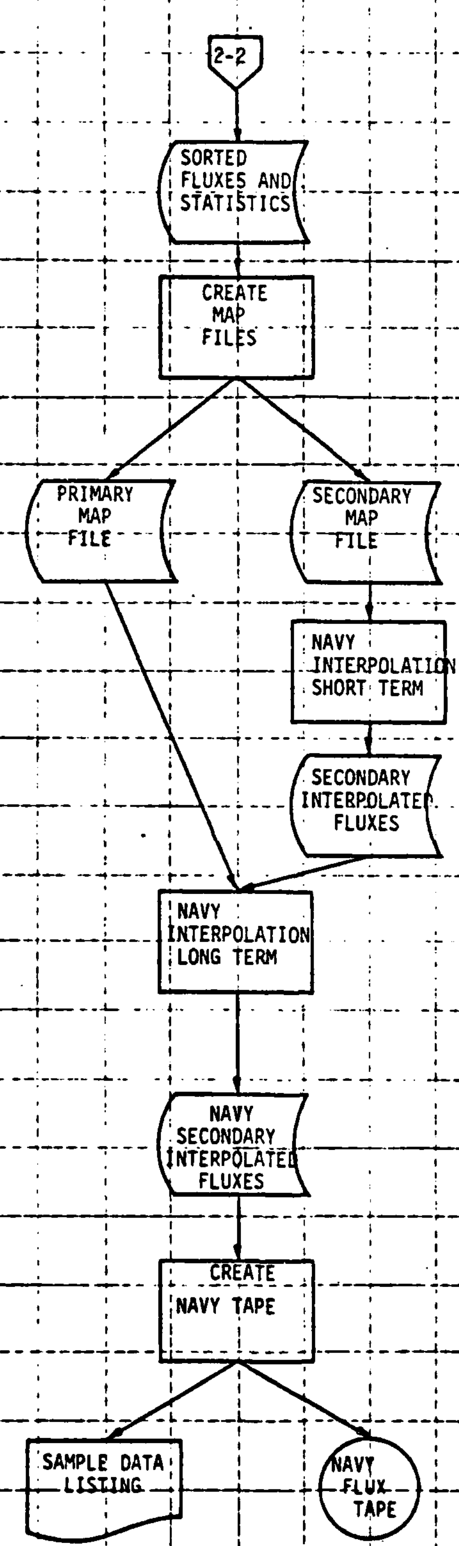
Procedure SYSTEM OVERVIEW Drawn By N. SAMUEL



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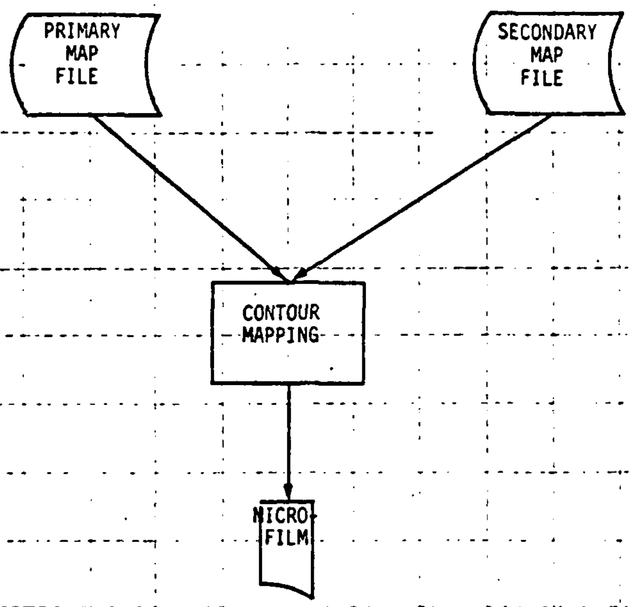

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PROCESS TDF-11 DATA

I. Objective

The purpose of this procedure is to edit and reformat data from the the TDF-11 data set. A limited edit check is made on each record. The procedure processes a number of Marsden squares from a single input tape supplied in TDF-11 format.

II. Description

A number of magnetic tapes were received in TDF-11 format containing data stored by Marsden squares (10 degree squares). These tapes included data both inside and outside of the tropical Pacific Ocean study area. Each TDF-11 tape was processed to ignore observations outside the study area, check for duplicate records, perform limited edit procedures, create compact output files, and produce cumulative density maps.

A single input card to the procedure controls the number of files (Marsden squares) to be processed from each tape. End-of-file designations on the TDF-11 data tapes consisted of a one-word record with no observations. These EOF's were not recognized by the standard CDC 7600 procedures and are thus incorporated into the Fortran code for this procedure.

Initial editing procedures reject all records that are not within the tropical Pacific study area. Secondary editing checked ranges of specific variables and makes consistency checks between variables. If the following edit checks are not met the record will be rejected:

1) $0 <$ air temp < 40
2) air temp data present
3) air sea temp diff with $\pm 1°$ of air temp - sea temp.

Additional editing occurred that resulted in some variables bring set to default values:

1) Surface pressure $\leq$ 950 mb or surface pressure $\geq$ 1050 mb then surface pressure = default

2) Dew point temp $\leq$ 0 or dew point temp > air temp + .1°
then dew point temp = default.

3) Surface temperature < 0 or surface temperature > 38° then surface temperature = default.

4) If cloud amount $\geq$ total amount low then both are defaulted.

Variables extracted from the TDF-11 data are selected to correspond with those of the RSOND file. Humidity is converted to g/kg values from either the wet bulb temperature or dew point temp. Wind measurements are converted to zonal and meridional components (meters/second).

Observations that meet the edit criteria are output as two word packed binary records with an additional (third) word as a sort key. The sort key contains the 5-degree-grid location and the date of the record. The sort key is subsequently used for sorting observations chronologically into appropriate 5-degree-grids. The packed binary records are output to an interim file. A density map is updated for each TDF-11 file processed. This density map is a cumulative count of the number of records successfully processed within each 5-degree-grid.

III. Input/output

Input consists of:

1) JCL cards specifying the TDF-11 data tape to be processed,

2) the density map file to be updated, and

3) an input card indicating the number of Marsden squares to be processed.

Ouputs are:

1) A summary of the records edited for each Marsden square,

2) an updated density map of observations processed in the study area, and

3) an output file of packed binary records of TDF-11 observations.

PROCESS FISHERIES DATA

I. Objective

The goal of this procedure is to edit and reformat records from the FNWC Marine Climatological Data (Fisheries Data). Range and consistency checks are performed and a limited check for duplicate records is made. A density map is produced indicating the number of records processed in each 5-degree-grid. Records are output in packed binary form with a sort key attached.

II. Description

A number of magnetic tapes containing Fisheries Data from 1972-76 were obtained. These tapes have either 12 files (1972) or 6 files (1973-76). The 1972 data is split into two tapes - one tape for the eastern Pacific and the second tape for the western Pacific. A single file contains the observations for each month. Subsequent years (1973-76) cover the entire Pacific area, but are split into two parts. The first tape contains records of January to June, the second tape has records from July to December.

Fishery Data records are initially rejected if they are outside the study area. Editing insures the presence of date, wind, and air temperature data. Secondary editing sets missing values to their appropriate defaults and requires the following:

1) $0° < \text{Air temp} < 40°$

2) Air sea temp diff within $\pm$ 1° of air temp - sea temp.

Humidity is converted to g/kg units and wind components are converted to zonal and meridional values in meters/second. Records are checked for duplication against the two previous records. All variables except cloud types are checked. If a duplicate is found the first record processed is kept and the second rejected.

Observations that pass the edit criteria are output as packed binary records of three words. The first word contains a sort key indicating the 5-degree-grid where the record was found and the date. An interim file of these packed binary records is created for subsequent use. A density map of the number of observations accumulated in each 5-degree-grid is produced.

III. Input/output

Input consists of:

1) JCL cards specifying the Fisheries Data tape to be processed, and
2) the density map to be updated.

Outputs are:

1) A summary of the records edited for each file processed,
2) an updated density map of observation processed in the study area, and
3) an output file of packed binary records of Fisheries observations.

SORT TDF-11 DATA

I. Objective

This procedure sorts the file of packed binary TDF-11 records. The first word of each three-word record is the sort key. This key contains the 5-degree-grid location and date of the observation.

II. Description

The NCAR sort utility BBSORT is used to sort the TDF-11 data into chronological order within each 5-degree-grid. The sort of the TDF-11 data was executed in 5 steps: The first four steps sorted a number of packed TDF-11 output tapes onto a single sorted tape. The fifth step merged these presorted tapes onto a single output volume. This single output volume requires four output files (approximately 15 million words).

III. Input/output

Inputs are:

1) Sort input volume and
2) sort input control cards (see BBSORT documentation in NCAR manual).

Outputs are:

1) A list of records and words sorted and
2) a sort output file.

SORT FISHERIES DATA

I. Objective

This procedure sorts the file of packed binary Fisheries records. The first word of each three-word record is the sort key. The key contains the 5-degree-grid location and date of observation.

II. Description

The NCAR sort utility BBSORT is used to sort the Fisheries data in the same way as the TDF-11 data is sorted. Only one sort pass is required for the Fisheries data. The sorted output volume (SRTFSH) contains approximately 44,000 records.

III. Input/output

Inputs are:

1) Sort input volumes and
2) sort input control cards (see NCAR documentation on BBSORT).

Outputs are:

1) A list of records and words sorted and
2) a sort output file.

MERGE MARINE DATA

I. Objective

The procedure creates the final marine data files after merging the TDF-11 and Fisheries records. Duplicate records between the Fisheries data and TDF-11 data after 1972 are removed. A final density map of the combined data sets is created.

II. Description

The merging of TDF-11 and Fisheries data is a two-step procedure. The sorted output files from the SORT TDF-11 and SORT FISHERIES procedures are merged together (using BBSORT) to produce a final marine data set. The marine data set is read and files of 5-degree-grids are created. Duplicate records that occur after 1972 are removed. The routine checks up to 20 previous records for duplication and the current record is rejected if a duplicate is found. All accepted records are written onto the appropriate volume and file (unique for each 5-degree-grid). A final density map of all the marine observations by 5-degree-grid for each year is produced.

III. Input/out (merge process)

Inputs are:

1) The sorted TDF-11 files and
2) sorted Fisheries files.

Outputs are:

1) A list of the density map of marine records,
2) a density output file, and
3) a file of the marine records.

LONG TERM STATISTICS

I. Objective

The averages, standard deviations, and number of observations for 11 variables (Lat, Long, T_a, U, V, T_s, Humidity, Pressure, Cloud Amount, Low Cloud Amount, and U magnitude) were calculated for each calendar month and each 5-degree-grid during the 20-year study period. These statistics were stored on direct access file where the long-term monthly value for each 5-degree-grid could be accessed independently. In addition, statistics describing the spatial and temporal distribution of the data were calculated and output on the line printer and 35 mm graphics.

II. Description

The result of the Phase I operations produced a final marine data file that combined the TDF-11 and Fisheries observations into a 5-degree-grid system. Each 5-degree-grid of marine data was processed chronologically and the long term (20 year) monthly statistics for each of 11 variables were calculated. These long term values were stored on a direct access volume (SEALNG) with a unique file for each 5-degree-grid. This organization allows the long term statistics for each grid to be processed independently of the other grids. These statistics were also output on the line printer.

To describe the spatial and temporal distribution of data, the number of observations in each 1° square was found and printed for each of the 20 years, as well as for the whole 20 year period. For an average month, the number of observations for each standard reporting hour was printed and plotted by year, as was the number of observations in each season and the number in each third of

January, April, July and October. The average latitude and longitude relative to the SW corner of the square was also printed and plotted by year.

III. Input/output

Inputs are:

1) File of Marine observations.

Outputs are:

1) Long term statistics file (SEALNG).
2) Two line printer pages showing the distribution of the data and the long term statistics as written to SEALNG.
3) Four 35mm frames of graphics showing the data distribution by year.

SHORT TERM STATS AND FLUXES

I. Objective

The monthly statistics and heat fluxes are generated from the observed marine data. The bulk formulas used to calculate the fluxes are described in Appendix E. Editing of daily observations occurred for values exceeding 3 standard deviations from the long term mean statistics.

II. Description

Individual observations of marine data were processed chronologically and the values of T_a, q_a, and T_s compared to the corresponding long term mean. Observations with values that exceeded the mean by 3 standard deviations were not used in calculating the short term statistics. In addition, observations with a wind magnitude over 35 m/s were rejected from further calculations. This editing eliminated approximately 2% of the observations. Calculations proceeded within each 5-degree-grid until all observations within the study period (1957-76) were processed.

The short-term monthly statistics (mean and variance) for the basic variables (U, V, T_a, T_s, q_a), the number of observations used to calculate U, and the mean values for the variables (Umag, q_s, P, N_L, N_T,C_E, H, LE, Q_s, Q_B, T_x, T_y, $\overline{U'T'}$, $\overline{V'T'}$, $\overline{U'q_a'}$, $\overline{V'q_a'}$, $\overline{U'V'}$) were calculated. Values for the horizontal eddy fluxes ($\overline{U'T'}$, $\overline{V'T'}$, $\overline{U'q_a'}$, $\overline{V'q_a'}$, $\overline{U'V'}$) were only calculated if 10 or more observations were present for the month. These values were written to an output file with identification data. This output file was subsequently processed to form maps and chronological data sets of the statistics and fluxes for the Pacific Ocean. In addition to the individual monthly values,

an annual mean was formed for all variables where all 12 months of the year were represented. These individual annual means were also written to disk. These individual annual means were also written to disk, long term means of all variables were found for each calendar month, and these long term monthly means were written to disk. Finally, long term annual means were formed for all variables represented in all 12 long term monthly means, and these long term annual means were written to disk.

Besides writing these values to the disk file, some values were written on the line printer, and some were plotted against time for the 20 year period. Those variables printed each month and year are N_u, U_{mag}, T_s DT, q_a, D_q, C_E, H, LE, N_T, Q_s, Q_b, net heating, and the number of reject observations; where DT = $T_s - T_a$, $D_q = q_s - q_a$ and net heating = Q_s - H - LE $-Q_b$. Thirteen variables were plotted as monthly means, showing time series covering all twenty years. These were grouped into six frames; 1) Q_s, Q_b, H, LE; 2) T_s, T_a; 3) q_s, q_a; 4) N_T, N_2; 5) T_x, T_y; 6) net heating. A final seventh frame showed the mean annual cycle of these same variables.

The program (subroutine TSFLUX) has the capability to form the monthly means in a detailed manner, subdividing the square into 9 sub-squares and dividing the month into thirds, etc. In all calculations, however, the coarse procedure was used, whereby all observations within the 5 degree square and within the month were processed and lumped together to form the monthly mean.

III. Input/output

Inputs are:

1) Marine file of observations, and
2) SEALNG file of long term statistics.

Outputs are:

1) Report of short term statistical and flux calculations,
2) file of calculated data with ID fields,
3) line printer output of some variables, and
4) 35 mm graphics showing the 20 year time series of monthly values for some variables.

The choice of which versions of the bulk formulas to use in calculating the vertical heat fluxes is a perplexing problem. On the one hand one wants to use the formulas which parameterize the available measured fluxes most accurately. On the other hand, one wants to be able to compare the results of the calculations to the results obtained by other researchers, who either used different data sets or worked in different areas of the ocean. This is especially true if one wants to merge heat flux calculations from different researchers into a consistent global picture of oceanic heat fluxes. The problem is complicated by the fact that vertical heat fluxes obtained by eddy correlation and profile techniques by different researchers under different meteorological conditions seem to support different bulk formulations. This is even more true of the radiation measurements and formulas, where it makes sense that different water vapor content in the different climatic regions of the world affect radiative transmission. Thus measurements at different locations support different radiation formulas which use only the surface meteorology, ignoring the air column above.

For the latent and sensible heat fluxes we chose to use the formulations used by Bunker (1976) in his calculations of heat fluxes over the Atlantic. He has also used these to calculate heat fluxes over the Mediterranean and Indian Oceans. In addition, Nate Clark at Scripps is using these formulas to calculate the latent and sensible heat fluxes for the North Pacific. These formulas are the standard bulk formulas.

$$H = Cp \; p_a \; C_E \; V \; (T_s - T_a)$$

$$LE = L \; p_a \; C_E \; V \; (q_s - q_a)$$

The only real question is how to specify the exchange coefficient C_E. Bunker reviewed much of the available literature and fit a curve to the

data, relating the neutral exchange coefficient to the wind speed. To correct for the stability of the atmosphere over the ocean, he multiplied the neutral exchange coefficient by a factor which depends on the bulk Richardson number, following a paper by Deardorff (1968). Deardorff derived this bulk Richardson number factor from more exact profile theory. The neutral coefficients were also increased 10% to account for interference by ship's hulls, as suggested by data from BOMEX. Finally he ignored the difference in C_E for H versus LE, since H is only approximately 10% of LE, so that the difference is insignificant. Bunker presents a table of C_E values for various ranges of V and $(T_s - T_a)$, and we used these values. The decision to use Bunker's formulation was not difficult, in that he used much of the resent data, and alternate formulations for C_E do not give substantially different results. Thus, compatibility with other research was the most important consideration.

The data required to calculate these two fluxes, H & LE, are V, T_s, T_a, q_a. The saturated surface humidity, q_s, was calculated from the sea surface temperature by

$$q_s(T_s) = \frac{1580848985 * 10^{\frac{-2354}{T_s}}}{p}$$

which is consistent with the formula used to calculate the air humidity. All observations kept after the gross editing included V and T_a. If p was not included in an observation, a value of 1000 was used to calculate q_s. If T_s was not included, then neither H nor LE were calculated. If T_s was included but q_a was not, then H was calculated but LE was not.

The choice of formulas for solar radiation and net long-wave radiation is more difficult than for H and LE.

If the sun radiates at a constant rate, the daily solar radiative flux at the outside of the atmosphere can be calculated accurately for any given latitude and day of the year. The three factors that determine how much of this "external" solar radiation penetrates the ocean's surface are 1) the transmissivity of the clear atmosphere above the ocean, with the water vapor content being the most variable absorber; 2) the cloudiness and the type of clouds, which cause both absorption and scattering; and 3) the albedo of the ocean surface (the fraction of incident radiation which is reflected away).

To calculate the radiation that reaches the surface of the earth through a cloudless atmosphere, Bunker used the same tables used by Budyko (1963). In collaboration with Nate Clark we decided to use a harmonic formula developed by Gunter Seckel (at NOAA's National Marine Fisheries Service) which gives the same values for clear sky solar radiation at the surface as the Smithsonian Tables with a transmissivity of .7. Seckel found this formula to work well at low latitudes. Reed (1977) found good agreement between this formula and direct measurements on a research vessel traveling from the tropics to the Gulf of Alaska. This formula has the form,

$$Q_o = A_o + A_1 \cos \phi + B_1 \sin \phi + A_2 \cos 2 \phi + B_2 \sin 2 \phi$$

where $\phi = \frac{2\pi}{365} (t - 21)$; t = day number (Julian day) and the A's and B's are functions of latitude, l:

$$A_o = -32.65 + 674.76 \cos l \qquad A_1 = 19.88 + 397.26 \cos (l + 90)$$

$$A_2 = -1.32 + 16.10 \sin 2(l - 45) \qquad B_1 = -6.75 + 224.38 \sin l$$

$$B_2 = -1.04 + 29.76 \cos 2(l - 5).$$

These give Q_o in units of Ly/day. To convert to W/m^2 multiply by 0.4846.

To estimate the fraction of solar radiation lost due to cloud cover, Bunker used the formula $Q = Q_o\ (1 - aC - bC^2)$ where c is the total fractional cloud cover and a and b are constants. Seckel found this formula (with a = .3, b = .38) agreed with some oceanic observations. Our tests of this formula gave unrealistically low values of Q, and our final choice was that suggested by Reed (1977),

$$Q = Q_o\ (1 - .62C + 0.0019\ \alpha)$$

where α is the noon solar altitude, calculated by

$$\sin\alpha = \sin l\ \sin\ [23.45\ \sin(t - 82)] + \cos l\ \cos[23.45\ \sin(t - 82)]$$

where l and t are latitude and Julian day as above, and the trigonometric arguments are in degrees.

Following Reed, when the cloud cover is less than 0.2, no cloud correction is applied. Since cloud cover is reported in octants, this means that clear sky radiation is used for the case of 0/8 and 1/8 cloud cover. Nate Clark also uses Reed's formula.

The last factor affecting solar radiation is reflection from the sea surface, so that another correction term must be included, (1-A), where A is the albedo. Bunker used climatic average albedo values developed by Payne (1972) for the Atlantic Ocean. Again in collaboration with Nate Clark, we decided to use Payne's values, which vary with the month and latitude.

For the net long-wave radiation component we used the results of an observational study by Simpson and Paulson (1979) at a mid-ocean station. They concluded that clear sky net long-wave radiation can be computed from the vapor pressure, e, the surface temperature, T_s, and the air temperature T_a by

$$Q_{bo} = \varepsilon\sigma T_s^4(0.39 - 0.05\ e^{\frac{1}{2}}) + 4\ \varepsilon\sigma T_s^3(T_s - T_a)$$

which is Brunt's formulation with a correction for the air-sea temperature difference added by Berliand. ε is the emissivity of water (.97) and σ the Stefan-Boltzman constant. To correct this clear sky estimate for cloud cover we chose to use Laevastu's formula

$$(1 - aC)$$

where C is tenths of cloud cover and a varies with cloud type (a = .9 for stratocumulus, a = .6 for alto stratus and a = .25 for cirrus). Reed (1976) found that a similar formula fit data from various oceanic sites around the world. Simpson and Paulson recommend this formula with a = .8 constant. Bunker used Budyko's long-wave formulas which are nearly identical to the above (the constant a is allowed to vary, but the values may be different than Laevastu's). Nate Clark is using the above formulas with a = .8. The long-wave term is a small one in the surface heat flux budget, and the difference caused by the constant in the cloud correction factor should have negligible effects.

Thus the data necessary to calculate the solar radiation are the date and latitude, which are always present on all observations, and the total cloud cover. If the total cloud fraction was not reported, but the low cloud fraction was, then the low cloud fraction is used in the cloud correction factor. If neither cloud fraction was reported, the solar radiation was not calculated.

The data needed to calculate the net-back long-wave radiation are air and surface temperature, water vapor pressure calculated from air humidity, cloud cover and cloud type. Air temperature is present in all observations; if either air humidity or surface temperature was missing, long-wave radiation was not calculated. If neither low nor total cloud fractions were reported, long-wave radiation was not

calculated. If either or both of these cloud fractions were reported, then this information was used together with the data describing low, medium and high cloud types (if reported) to determine what part of the cloudiness was caused by low, medium or high clouds. This was used to assign a value to the constant, a, in the cloud correction factor, with a = .9 for low, a = .6 for medium, and a = .25 for high clouds. If the proportions of low, medium and high clouds could not be determined, an average value of a = .75 was used.

The outcome of this is that for H, LE and Q_b we used identical or nearly identical formulas to those used by Bunker and Clark. For solar radiation we used the same formulas as Clark (making a consistent composite Pacific Ocean map possible) but different from Bunker.

SUMMARY OF HEAT FLUX FORMULAS

Sensible Heat

$$H = Cp\ \rho_a\ C_E\ \ V\ \ (T_s - T_a)$$

C_E from
Bunker

Latent Heat

$$LE = L\ \rho_a\ C_E\ \ V\ \ (q_s - q_a)$$

C_E from
Bunker

Solar Radiation

$$q_s = (1 - A)\ (1 - .62\ C + .0019\ \alpha)\ Q_o$$

A from Payne

Q_o from Seckel's harmonic formula

Net Long Wave Back Radiation

$$Q_b = (1 - ac)\ \{\varepsilon\sigma T_s^4(.39 - .05e^{\frac{1}{2}}) + 4\ \varepsilon\sigma T_s^3(T_s - T_a)\}$$

a from Laevastu = f(cloud type)

BCW/smr

9/80

NAVY INTERPOLATION

I. Objective

A number of long term (20-year) and monthly values of the secondary flux data were not calculated due to missing observations or lack of adequate data. Two interpolation routines were developed to fill in the missing values for the secondary variables L_E, H, Q_s, and Q_B. This interpolation was completed in fulfillment of a contract to supply these fluxes to the Navy.

II. Description

Two interpolation schemes were used; one for the long term (20-year) means and a second for the individual months. These are discribed separately below as "long-term interpolation" and "monthly interpolation".

Long Term Interpolation

The interpolation of long-term values for 5-degree-grids was conducted when the data was missing (1.E36) or when less than 5 months were used to determine the long-term mean. The interpolation scheme required that at least two neighboring 5-degree-grids were used to calculate the new value. Neighboring points that were themselves interpolated were not used in the calculation. A preliminary search of the four adjacent points to the north, south, east, and west was conducted. If one or less of these neighbors could be used to calculate the interpolated value, a secondary east, west search was conducted. The secondary search was continued simultaneously in both directions until a total of two or more valid points for interpolation were achieved. The value of the missing 5-degree-grid point was determined as a mean of its neighboring valid points that were found by the primary and

secondary searches. The interpolated value was biased by adding 3000 to distinguish it from other flux values.

Monthly Interpolation

The monthly interpolation scheme filled in missing 5-degree-grid points for the monthly and annual flux data. Only a primary search of the adjacent north, south, east, and west points was conducted. Again, previously interpolated points or points with missing data were skipped. The interpolated value for the 5-degree-grid was calculated using the long-term mean as a base. This base was modified by the average of the deviations from the valid adjacent points from their doing term means. Interpolated values were biased by adding 3000 so they could be distinguished from non-interpolated points.

III. Input/output

Inputs are:

1) The file of secondary flux calculations.

Outputs are:

1) The modified file of secondary fluxes.

CREAT NAVY TAPE

I. Objective

A magnetic tape of interpolated heat fluxes (H, LE, Q_s and Q_B) at 5-degree-grid points is produced for the NAVY. Monthly, annual, and long term fluxes are written to tape in chronological order. Interpolated values less than zero for all fluxes except LE are reset to zero (+ bias). Flux values over land masses are defaulted to 9999.9.

II. Description

The NAVYFX file of interpolated flux calculations are processed chronologically. A matrix of data for each flux by 5-degree-grid coordinates is created and written to tape. The H, Q_s, and Q_B fluxes that have interpolated values less than zero are reset to zero. Any flux values occurring over a land mass are set to the default code (9999.9). Each matrix is written with a year, month, and variable number code in integer format.

III. Input/Output

Inputs are:

1) File of interpolated flux calculations.

Outputs are:

1) Magnetic tape of flux data, and
2) sample data output.

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Tropical Pacific Surface Flux Tape

Description

The tape contains flux calculations for sensible (H), latent (LE), absorbed solar (Q_S), and back infrared (Q_B), for the tropical Pacific Ocean (40°S to 30°N latitude and 110°E to 70°W longitude). Calculations are made for each 5-degree grid identified by the latitude and longitude coordinates of the lower left corner, i.e., 20°N latitude and 80°W longitude cover the area 20°N-24.9°N and 80°W-75.1°W. The flux calculations are presented in matrix form with dimensions of I=14 and J=36. The matrix coordinates map onto the 5-degree-grid points where I corresponds to latitude changes and J corresponds to longitude changes. The corners of the data map have the following matrix locations

40°S lat 110°E long = (1,1)

25°N lat 110°E long = (14, 1)

40°S lat 75°W long = (1, 36)

25°N lat 75°W long = (14, 36)

Tape records are fixed format 3030 character blocks. Each record contains identification data and one flux matrix (either H, LE, Q_S, or Q_B). Identification data indicates the year (1957=57), the month (Jan=1), and the variable number (H=1, LE=2, Q_S=3, and Q_B=4). The records are in chronological order. An additional month (13) is included for each year and has the annual mean flux calculations for that year. An additional year (77) is also included and contains the long term (20 year) mean fluxes for each (month=1-12) and the total long term mean fluxes for all data (month=13).

Interpolated data has been biased by adding 3000. This differentiates actual data from interpolated data. Subtract 3000 from the interpolated data to unbias the values. Default data was assigned to 5-degree points over land masses. The default value is 9999.9.

File Organization

Medium: Magnetic tape

Organization: Sequential

Label: None

Format: Fixed block, EBCDIC characters (odd parity), 9 channel, 1600 bpi.

Rec size: 3030 characters

File size: 1092 records

Sequence: Year (57-77)

Month (1-13)

Variable # (1-4)

Record Format

Element No.	Description	Format
1	Year eq. 1957=57	I 2
2	Month eq. Jan.=1	I 2
3	Variable eq. 1=H	I 2
4-507	Flux (I, J) I=1, 14; J=1, 36	F6.1

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pjl